

US Geological Survey Induction-Hazard Science

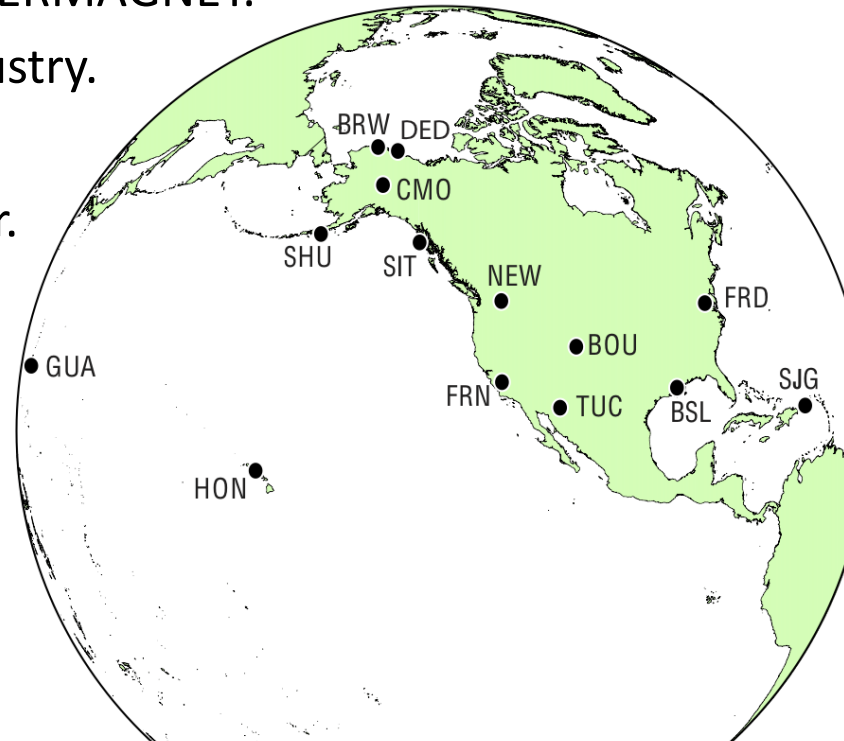
**Jeffrey J. Love, Carol A. Finn, E. Joshua Rigler
Geomagnetism Program
USGS Natural Hazards Mission**

**Paul A. Bedrosian
Crustal Geophysics and Geochemistry
USGS Energy and Minerals Mission**

USGS Geomagnetism Program

geomag.usgs.gov

- Part of a USGS Natural Hazards Mission.
- DOI representation in the National Space Weather Program.
- Monitor Earth's magnetic field at ground-based magnetic observatories.
- Report data with high accuracy, resolution, and reliability.
- Customers: Air Force, NOAA, NASA, GFZ, NICT, industry, academia.
- Promote operations around the world: INTERMAGNET.
- Operational partnership with oil & gas industry.
- Conduct research of societal importance.
- Carol A. Finn, Geomagnetism Group Leader.
- 16 staff, 14 observatories.
- Budget: \$1.9 million/yr.



President's 2016 budget for USGS Geomagnetism Program: Increase of \$1.7 million/year to \$3.6 million/year

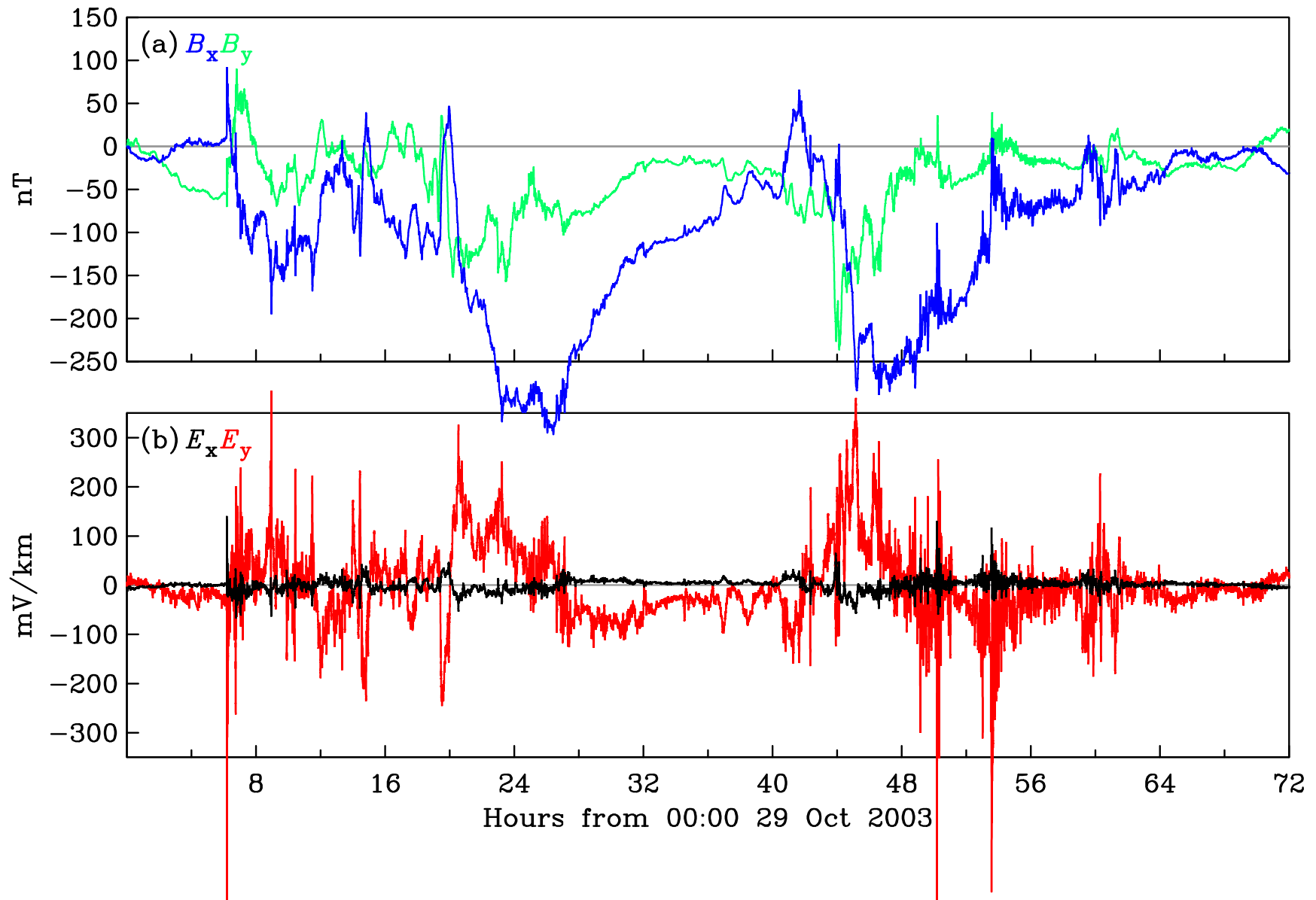


What this would support:

- New geomagnetic observatories: US, Pacific, South Pole.
- Geoelectric monitoring at some observatories.
- Magnetotelluric surveys: augment those of NSF EarthScope Program.
- 3D modeling of lithospheric electrical conductivity.
- Scenario assessments of induction hazards in US.
- Study feasibility of providing real-time geoelectric maps.
- Support international geomagnetic monitoring and data exchange.
- Induction-hazard research of importance for National economy and security.
- Relieve Air Force Weather Agency of financial support for USGS operations.

Geomagnetic and Geoelectric Data

Japan Meteorological Agency, Kakioka, 29-31 October 2003



Input signal
time series



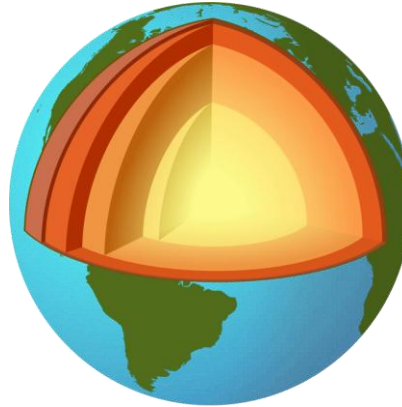
Convolution
through a filter



Output signal
time series



Geomagnetic
variation

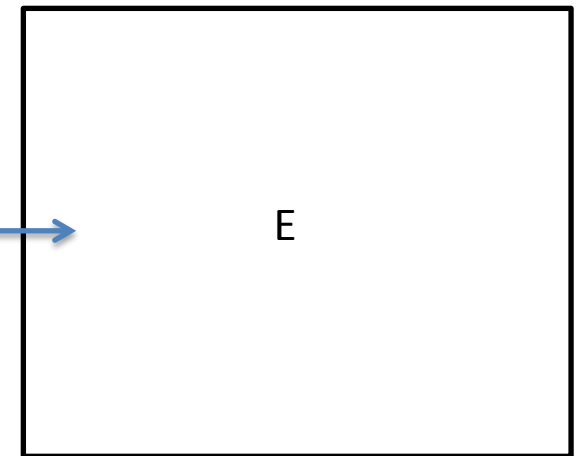
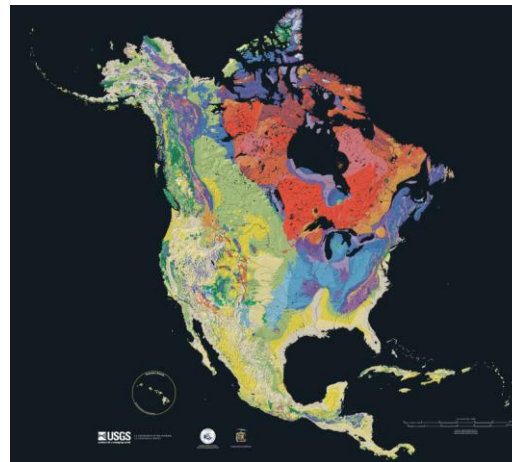
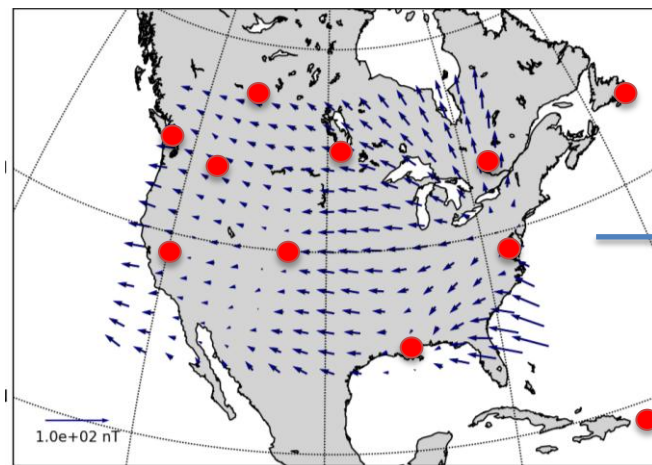


Geoelectric
field

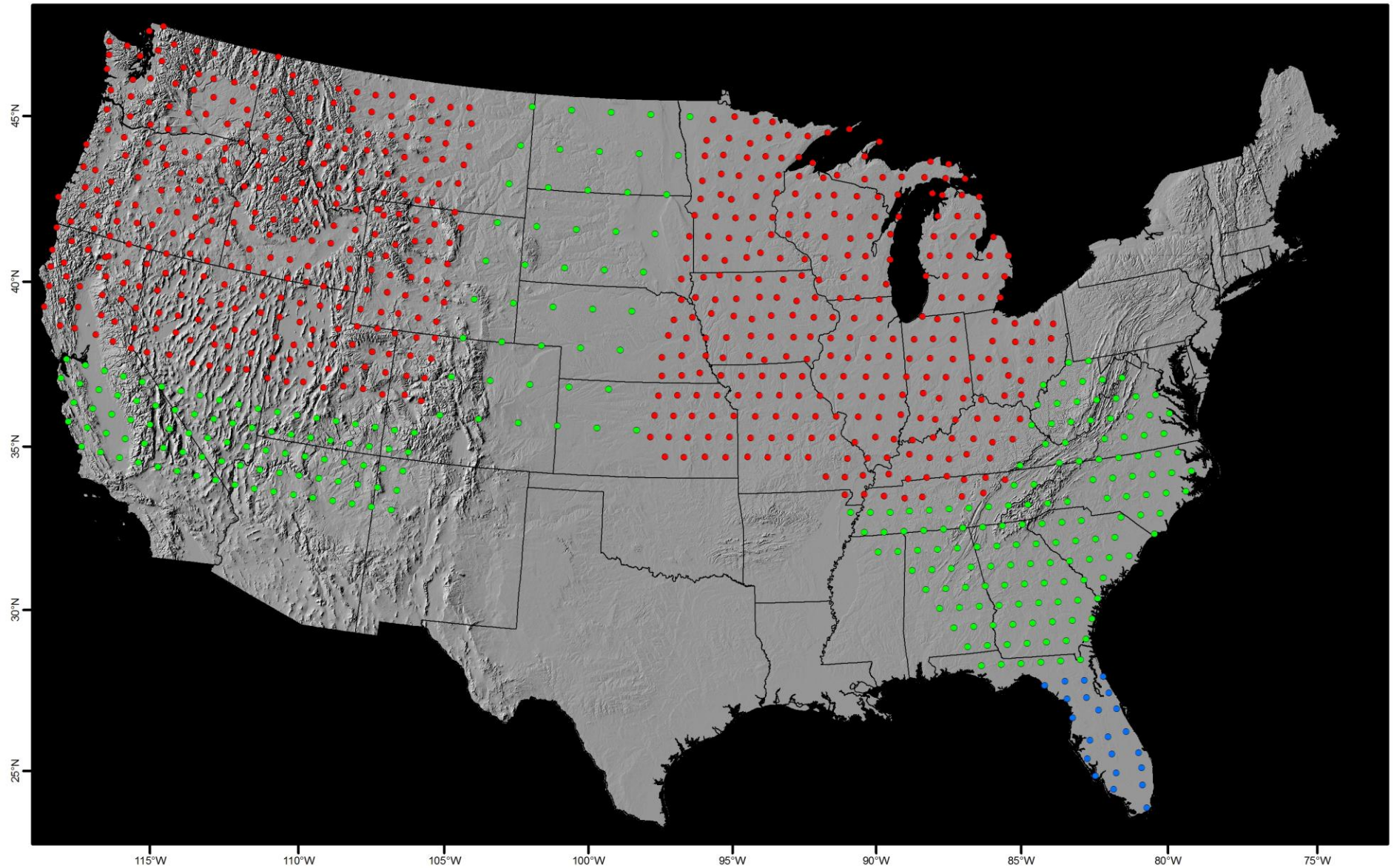
Map of
geomagnetic variation

Model of
lithospheric conductivity

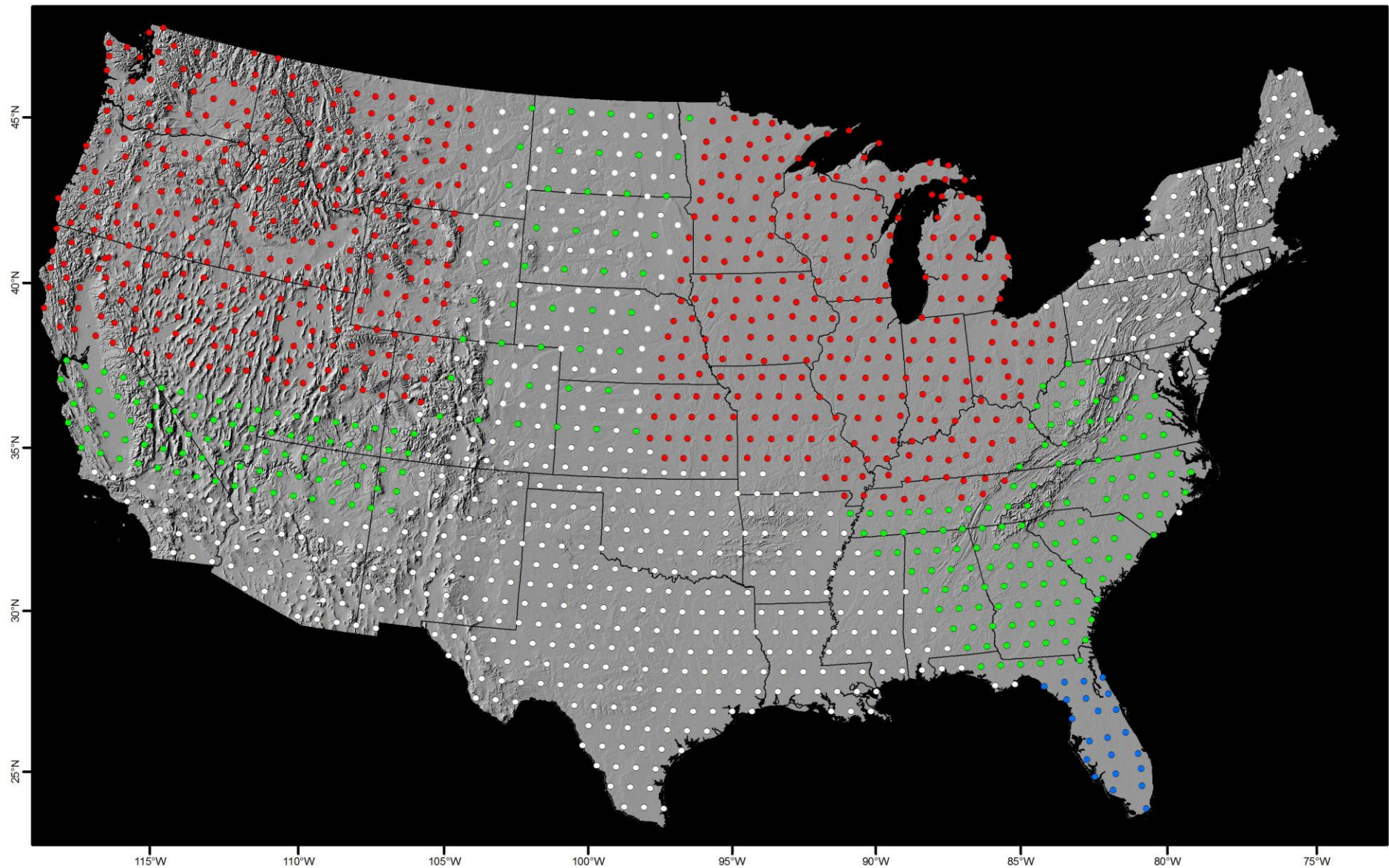
Map of
geoelectric variation



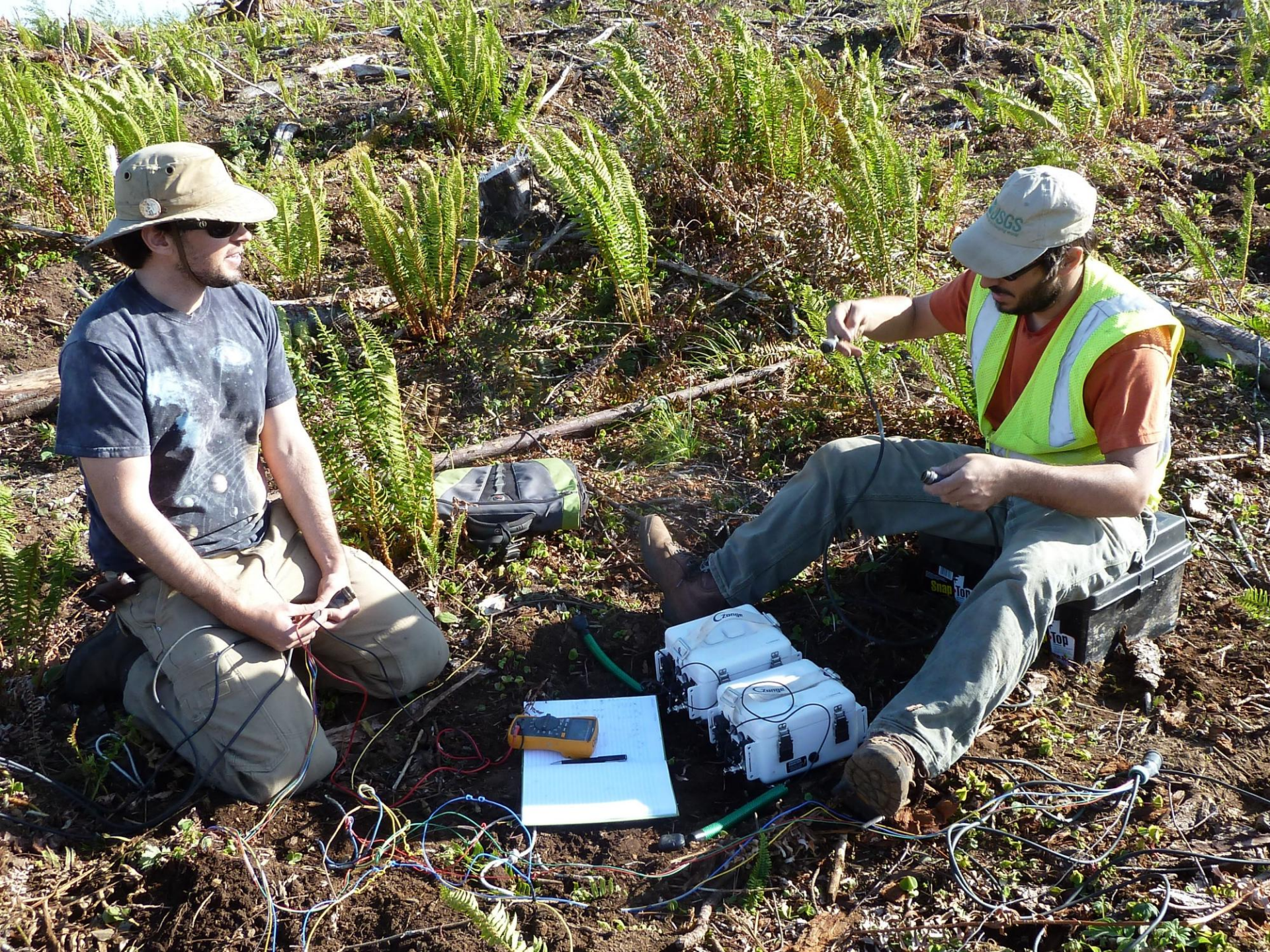
NSF EarthScope MT survey by 2018 with recent USGS work in Florida.



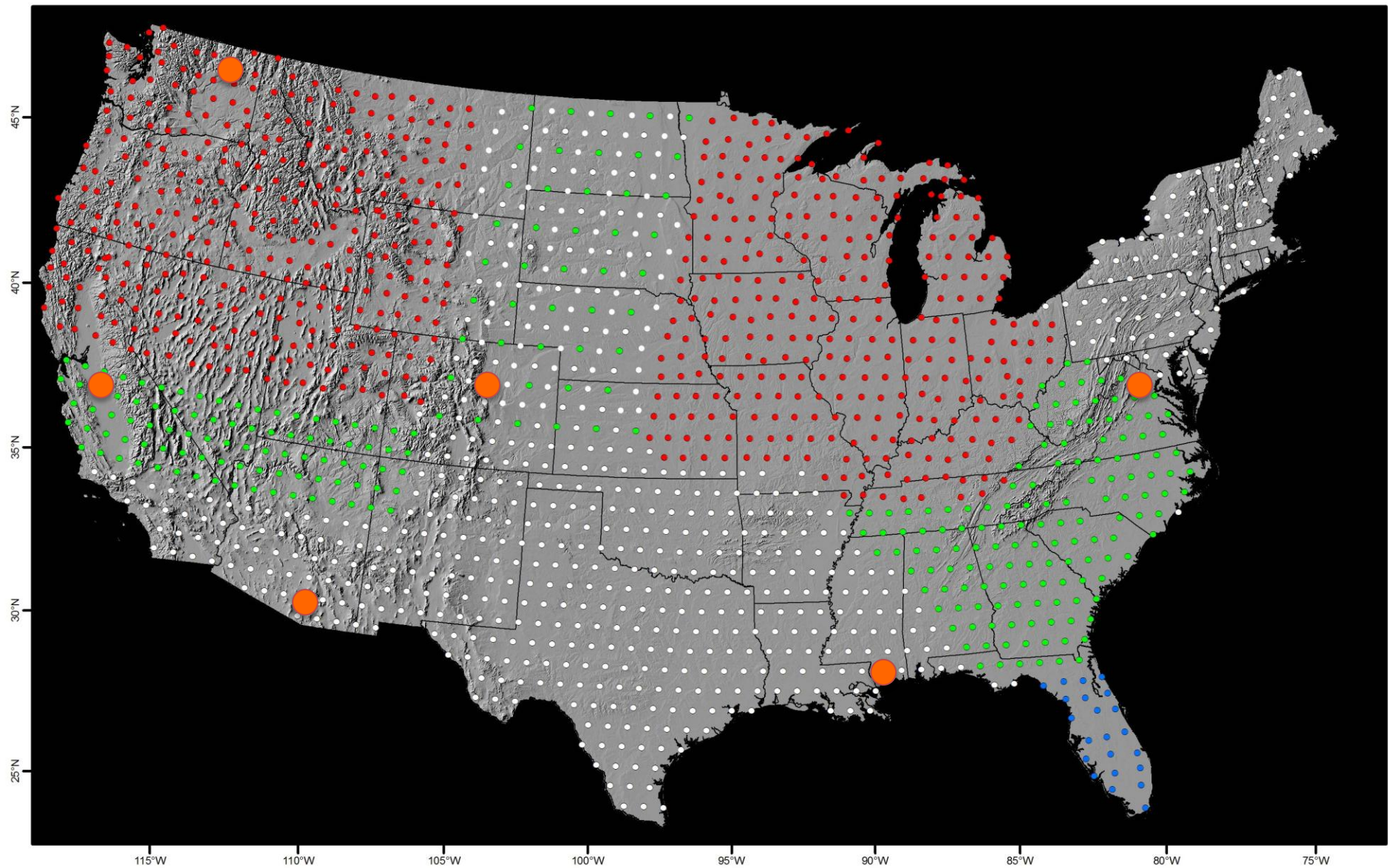
Proposed USGS MT augmentation (white)



Will provide data useful for induction-hazard science and
for fundamental geological understanding of the Earth's lithosphere.



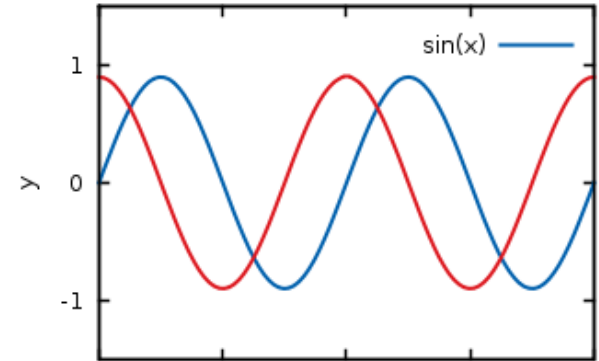
EarthScope and USGS MT + USGS observatories



Two classical transformations:

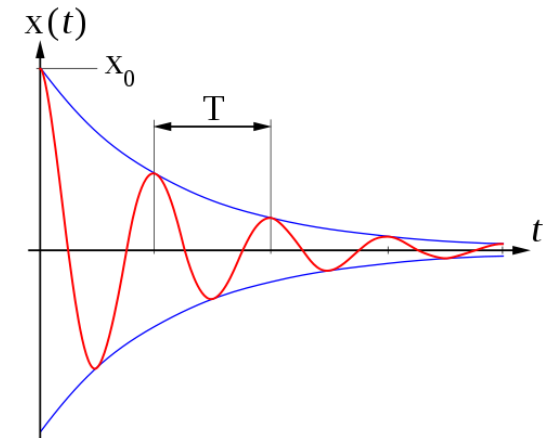
Joseph Fourier(1768-1830)

Most magnetotelluric algorithms are based on Fourier analysis: Stationary time series can be decomposed into periodic sinusoids. Does not lend itself to causal algorithms.



Pierre-Simon Laplace (1749-1827)

Transient and aperiodic time series can be decomposed into exponential “moments” -- sinusoids but with complex frequencies.



Need to develop “time causal” algorithms for E-field estimation.

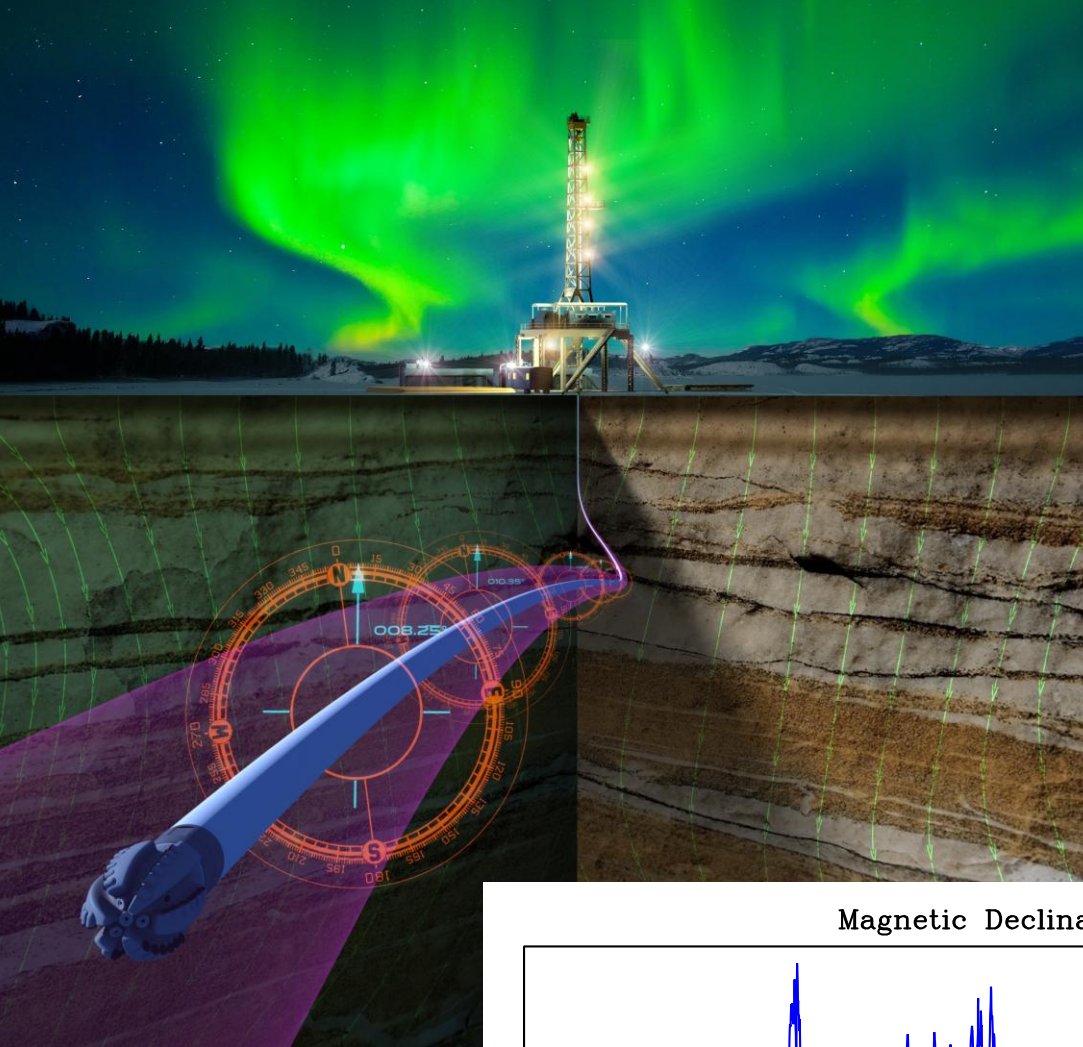
- Love, J. J. & Swidinsky, A., 2014. Time causal operational estimation of electric fields induced in the Earth’s lithosphere during magnetic storms, *Geophys. Res. Lett.*, 41, 2266-2274, doi:10.1002/2014GL059568.
- Love, J. J. & Swidinsky, A., 2015. Observatory geoelectric elds induced in a two-layer lithosphere during magnetic storms, *Earth Planets Space*, in press.



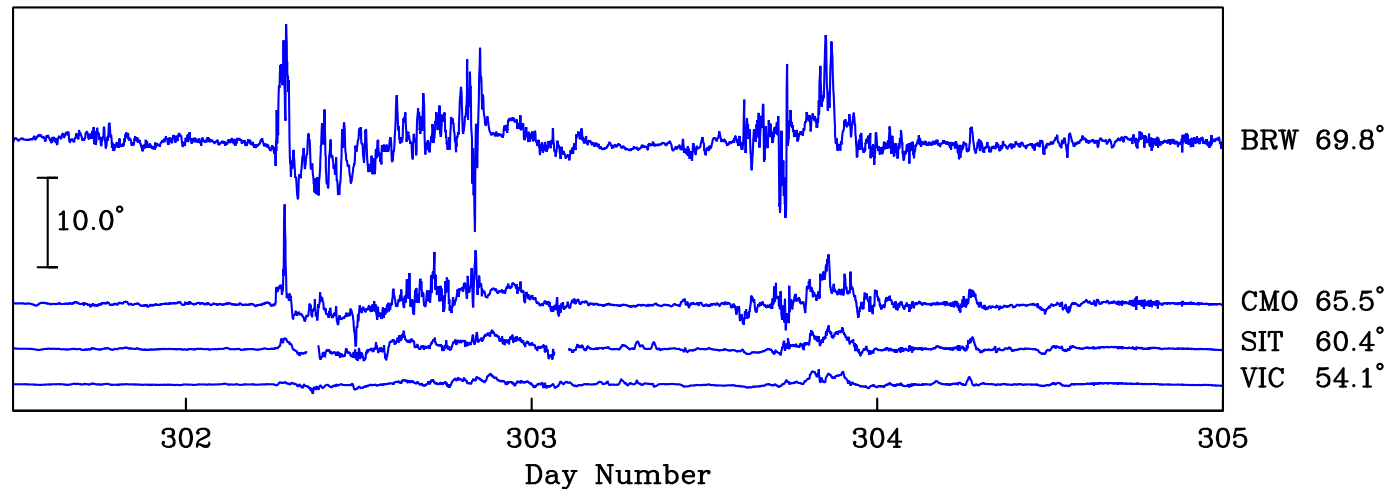
USGS Induction-Hazard Science:

- Improved geomagnetic monitoring.
 - Geoelectric monitoring.
 - Magnetotelluric surveys to estimate lithospheric conductivity.
 - Assessments of induction-hazards.
 - Goal of real-time geoelectric mapping.
 - Research of societal importance.
-
- Love, J. J., Rigler, E. J., Pulkkinen, A. & Balch, C. C., 2014. Magnetic storms and induction hazards, *Eos Trans. AGU*, 95(48), 445-446, doi:10.1002/2014EO480001.

Magnetic orientation for directional drilling for oil & gas: A public-private collaboration



Magnetic Declination Oct 28–31, 2003



Schlumberger

USGS
science for a changing world